Put Your Smartphone Down: Preliminary Evidence that Reducing Smartphone Use Improves Psychological Well-being in People with Poor Mental Health

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Abstract

Smartphones have become an integral part of our daily lives. Although there is evidence that there are positive aspects to smartphone use, overuse has also been shown to lead to poorer mental health. Surprisingly, there has been no empirical research investigating whether decreasing smartphone use improves mental health. Here, we examined whether an intervention designed to reduce smartphone use would have a positive impact on people's psychological well-being. Participants (n = 60) completed a baseline inventory of psychological measures and questionnaires about their smartphone use, and then installed an app on their smartphone to objectively monitor their smartphone use. Following a 2-week intervention designed to reduce their smartphone use, participants again completed the inventory of psychological measures. We predicted that reductions in smartphone use would result in improvements in psychological well-being, particularly for those individuals whose psychological well-being was poor to start with. To test this prediction, we assigned participants to one of two symptomology groups according to their scores on clinical measures of depression and anxiety. Participants with higher levels of symptoms of depression or anxiety at baseline showed significant improvements in their psychological outcomes after the intervention, but participants with lower levels of symptoms of depression or anxiety did not. We conclude that smartphone interventions may be particularly beneficial for people whose mental health is poor to begin with.

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Wei Liao

Table of Contents

List of Figures

List of Tables

Introduction

Technology is widely used in today's society, particularly among young people. Approximately one out of five university students report that they had access to a computer beginning at the age of 5 to 7 (Kruisselbrink Flatt, 2013). Novel technologies continue to emerge and adoption rates have grown over the past decade. According to a Pew Research Centre report published in 2015, nearly two-thirds (64%) of Americans own a smartphone[1], up from 35% in 2011 (Smith, 2015), and young adults are the most likely group to own a smartphone. We have come a long way from when phones were originally connected to the wall. Moreover, unlike basic mobile phones (or cell phones), which were only capable of voice calling and text messaging, today's smartphones offer greater computing power than many desktop computers from a decade ago . Smartphones have not only replaced mobile phones, but they have also replaced personal computers in some user groups (Samaha & Hawi, 2016). Owing to the large screen size and inherent mobility, smartphones allow individuals to use technology anytime and anywhere. What is more, with a smartphone, a person can make calls, send e-mails, play video games, surf the Internet, interact on social networks (e.g., Facebook), use instant messaging (e.g., Whatsapp), and so on. Given their usefulness, smartphones have now become considered an essential part of the lives of young people across the world (Samaha & Hawi, 2016).

Positive effects of smartphone use

In addition to the obvious practical benefits of smartphone use, smartphones also have some psychological benefits including the opportunity to fulfil psychological needs and strengthen bonds with others (Bardi & Brady, 2010; Chen & Katz, 2009; George & Odgers, 2015; Kang & June, 2014; Wei, 2008). For example, Kang and June (2014) carried out a

[1] Although smartphones have superseded mobile phones/cell phones, people use the terms interchangeably to refer to smartphones.

study to examine the link between smartphone use and basic human needs. In a self-administered web survey that was completed by 398 American and 331 Korean college students, participants were asked to rate 28 statements about whether the use of their smartphone met various basic needs, including their emotional needs (e.g., "By using my smartphone, I can have an enjoyable time"), safety (e.g., "By using my smartphone, I can rely on the phone in the case of danger or trouble"), belongingness (e.g., "By using my smartphone, I can meet nice people"), love for others (e.g., "By using my smartphone, I can get closer to important people around me"), respect (e.g., "By using my smartphone, I can enjoy a certain prestige"), self-esteem (e.g., "By using my smartphone, I can develop self-confidence"), and self-actualisation (e.g., "By using my smartphone, I can develop my potential to do work"). The American students ranked emotional needs/safety, self-actualisation, self-esteem, and belongingness as being important, while the Korean students ranked self-esteem, emotional needs, belongingness, self-actualisation, and safety as being important. Overall, both young Americans and Koreans believed that smartphone use had become an integral part of their everyday life, and fulfilled many of their basic needs.

For shy individuals, in particular, the instant messaging feature of smartphones may offer them protection from the stress of face-to-face interactions and enhance their opportunities for social interaction. Bardi and Brady (2010), for example, investigated why shy people use smartphone instant messaging. In their study, 55 undergraduates were first surveyed about their instant messaging use (e.g., "How often do you use instant messaging?"), and then completed a 13-item Instant Motives Scale to measure their motives for using instant messaging and a 9-item Shyness Scale to measure their level of shyness. Bardi and Brady found that participants' primary reasons for using instant messaging differed depending on their level of shyness. Although the majority of participants indicated that personal contact was their main motive for using instant messaging, individuals with high levels of shyness reported that decreasing loneliness was their main motive for using instant messaging. Bardi and Brady concluded that instant messaging via a smartphone may help socially-awkward people reduce their anxiety by allowing them to build connections with others without the anxiety of face-to-face contact.

In another study on the relation between smartphone use and social interaction, Cho (2015) found that the positive effect of smartphones on social interaction was not limited to people who suffer from shyness. Cho recruited a sample of 2,708 participants ranging in age from 20 to 50 years to complete a survey in which they were first asked to estimate the hours that they spent each day on two kinds of smartphone apps: communication apps (e.g., KakaoTalk) and social network apps (e.g., Facebook). Participants then completed measures of social capital previously used by Williams (2006). *Bonding* social capital was measured using an 8-item questionnaire (e.g., “There are several people who I trust to solve my problems”), and *bridging* social capital was measured using a 6-item questionnaire (e.g., “Interacting with people makes me feel like a part of a larger community”). Cho found that participants’ use of communication apps on their smartphones positively predicted both bonding social capital and bridging social capital, which then significantly reduced social isolation. Although this effect was shown for both younger and older adults, the effect of communication app use on social capital was stronger for younger adults than for older adults. Cho concluded that the communication apps have a notable role to play in improving individuals’ social capital, particularly for the younger generation.

In yet another study, Dissing, Lakon, Gerds, Rod, and Lund (2018) investigated the association between smartphone use, social integration, and tie strength (the degree of closeness in a relationship). University students (n = 737) were surveyed about who they had social contact with and how often they had that contact before being asked to record their smartphone use over a one-month period. Dissing et al. then derived measures of social integration and tie strength using participants' responses on the survey and the data on their smartphone use. Social integration consisted of two measures: *Social role diversity* in the number of social partners (mother, father, siblings, extended family, partner, and friends) with whom participants reported that they had frequent face-to-face contact or frequent non-face-to-face contact; and *Social network size,* defined as the number of people who participants called and texted during the month that their smartphone use was being recorded. *Tie strength* consisted of three measures: *Total contact frequency* with all social partners; *Total duration* of calls during the month of smartphone recording; and *Tie reciprocity*, the number of people with whom participants had reciprocated activity during the month of smartphone recording. Dissing et al. found that high social role diversity, regardless of whether the reported contact was face-to-face or non-face-to-face, was associated with a higher frequency and duration of calls and text messages during the month of smartphone recording. The authors concluded that smartphone use in their sample reflected self-reports of social interaction and social relations to a large degree, however, they also cautioned that their results may not be generalisable beyond their sample of young adults given that the pattern of and motivation for smartphone use has been shown to differ by age (e.g., Forgays, Hyman, & Schreiber, 2014).

Negative effects of smartphone use

While smartphones are recognised as a necessary and convenient device for many individuals, there is also a growing concern about some of the potentially negative consequences of smartphone use (e.g., Twenge, 2017, but see Orben & Przybylski, 2019). For example, there is some concern that smartphones can become addictive. In one study on smartphone addiction, for example, Clayton, Leshner, and Almond (2015) examined the effects on cognition, anxiety, and physiology when iPhone users were unable to use their phone for a short time. In that study, participants ($n = 41$) were randomly assigned to one of two experimental groups. In group one, participants were allowed to keep their iPhone with them while they were given 5 mins to complete a word-search puzzle; they were then given another 5 min to complete a second word-search puzzle, but this time, without their iPhone. Before being asked to complete the second puzzle, researchers told participants that their iPhone was interfering with the measurement of their blood pressure so it would need to be moved further away from them in the room. At min 3 of the second word-search puzzle, the researchers called the participant's iPhone and let it ring six times (around 20s) before ending the call. In group two, participants were asked to complete the first word-search puzzle without their iPhone and to then complete the second word-search puzzle with their iPhone. Unlike for group one, researchers called the participant's iPhone during the first puzzle. All participants were instructed not to get up from their cubicle for any reason unless they were asked to do so.

Researchers measured participants' blood pressure and heart rate at baseline and then again at minute 4 of each 5-min word search. After completing each word-search puzzle, participants were asked to complete the State-Trait Anxiety Inventory (STAI) and two self-report questions about the unpleasantness and pleasantness of the experience. In both groups, when participants were not able to answer their phones during the word-search task, they exhibited poorer performance on the word-search puzzles, reported higher levels of anxiety and unpleasantness, and their blood pressure and heart rate increased, compared to when they were allowed to keep their iPhone with them while doing the word-search task. Clayton et al. (2015) concluded that their participants experienced separation anxiety when they were not allowed to use their devices, which was accompanied by increases in blood pressure and heart rate. In turn, these changes reduced their attention or mental resources to perform tasks that required concentration.

In a similar study, Cheever, Rosen, Carrier, and Chavez (2014) explored individuals' anxiety when they were unexpectedly separated from their wireless mobile devices (WMD). A sample of 163 university students were randomly assigned to one of two groups: in one group, researchers asked participants to hand in their wireless devices for the duration of the experiment; in the other group, participants were allowed to keep their wireless devices but were instructed to keep them silent and out of sight. Participants were forced to sit quietly with no distractions during the study. All participants were asked to complete the state portion of the State/Trait Anxiety Inventory (STAI) three times at 20-min intervals in a large lecture hall. In the last 15 mins of the 75-min study period, participants were asked to complete a questionnaire to assess their daily technology use. Daily technology use was used to create three groups: low WMD users, moderate WMD users, and heavy WMD users. Cheever et al. found that overall, participants' anxiety increased over time, regardless of whether they had their device taken away or were allowed to keep their device close by but out of sight. In addition, heavy WMD users showed the strongest increase in anxiety over time compared to low WMD users whose anxiety levels did not change over time. Cheever et al. concluded that people who rely heavily on their smartphones might experience separation anxiety when access to their devices is restricted.

In addition to the negative effects of potential smartphone addiction, there is also evidence to suggest that constant use of smartphones may have a negative and lasting impact on users' cognitive functioning, including declines in attention, memory, delay of gratification, and academic performance (for review, see Wilmer, Sherman, & Chein, 2017). For example, in one study, Zheng et al. (2014) investigated the association between mobile phone use and inattention in a sample of 7102 (51% males) Chinese students ranging in age from 12 to 20. Participants were asked to complete questionnaires on phone use, and their teachers were asked to report on students' inattention. To measure the time spent on the phone, participants were asked to report whether they owned a phone, how long they used a phone, how much time they spent making phone calls per day, and how much time they spent on phone entertainment. To measure phone usage, participants were required to report how they answered the phone, where they put their phones during the day, and which mode they left their phone in at night (on/off/silent). To measure inattention, teachers indicated whether students exhibited any of nine inattention descriptions based on the Attention Deficit component of Attention Deficit/Hyperactivity disorder (ADHD) as defined by the DSM (4^{th} edn.). Inattention was defined when the teacher made six or more "yes" responses to the descriptions.

Zheng et al. (2014) found that compared with students without mobile phones, students who owned mobile phones had a higher prevalence of inattention. In addition, there was a positive relation between inattention and the time spent on phone entertainment, particularly among participants who spent more than 60 mins per day using their phone. On the basis of these data alone, however, it is impossible to draw a causal link between mobile phone use and inattention; although it is possible that mobile phone use may lead to inattention, it is equally likely that individuals with attention disorders are more likely to use their mobile phones. Thus, additional studies are needed in the future to explore the long-term directional effects of inattention and the time spent on mobile phones.

Some researchers have also shown that smartphone use may have a detrimental effect on academic outcomes. Junco and Cotton (2011), for example, examined whether instant messaging affected perceived academic outcomes. To do this, they conducted a web-based survey with a large sample of university students from four public universities (n = 4,491). To measure academic outcomes, students were asked to report how often they failed to complete their assignments because of their use of instant messaging. Responses were recoded as "No" if the students chose "never," while other responses (very frequently, somewhat frequently, sometimes, or rarely) were recoded as "Yes." To measure the frequency of instant messaging, participants were asked to report how much the time they spent sending and receiving messages per day. Students spent an average of 120 mins on a typical day chatting via instant messaging. Higher levels of instant messaging were associated with not completing assignments on time. Based on this finding, Junco and Cotton concluded that smartphone use could have a detrimental effect on academic outcomes.

Although Junco and Cotton (2011) examined the relation between technology use and perceived academic impairment, they did not include an objective measure of school performance, such as grade point average (GPA). Other researchers have explored the association between smartphone use, GPA, and satisfaction with life (Lepp, Barkley, & Karpinski, 2014; Samaha & Hawi, 2016). For example, Lepp et al. (2014) examined the potential relation between smartphone use, anxiety, academic performance, and satisfaction with life in a large sample of university undergraduate students (n = 536). Participants were asked to complete questionnaires to assess their subjective satisfaction with life, the total time spent on their smartphone per day, and the total number of text messages sent and received per day. Academic performance was objectively measured using participants' GPA obtained from official University records. Anxiety was measured using the Beck Depression Scale. Lepp et al. found that anxiety and academic performance mediated the association between smartphone use and satisfaction with life. Participants who exhibited a high frequency of smartphone use tended to have lower GPAs, higher anxiety, and lower subjective well-being or happiness compared to peers who used their smartphones less.

In another study, Samaha and Hawi (2016) explored the relation between smartphone addiction, stress, academic performance, and satisfaction with life. In that study, a sample of 249 university students completed an online survey. Smartphone addiction was measured using the Smartphone Addiction Scale – Short Version (SAS-SV), which identified the level of risk for smartphone addiction. Stress was measured using the Perceived Stress Scale (PSS) and satisfaction with life was measured using the Satisfaction with Life Scale (SwLS). Academic performance was measured using participants' GPA. Although there was no relation between level of risk for smartphone addiction and satisfaction with life, risk of smartphone addiction was positively related to perceived stress and negatively related to academic performance. That is, university students who scored high on the smartphone addiction scale had higher levels of perceived stress and lower GPAs.

Unfortunately, the correlational design used by Samaha and Hawi (2016) does not allow us to conclude that there is a cause and effect relation between smartphone addiction, stress, academic performance, and satisfaction with life. For example, smartphone addiction may have increased students' perceived stress, which reduced their levels of satisfaction of life, while on the other hand, students who experienced low levels of satisfaction with life may also have experienced higher levels of perceived stress, which might have increased their risk of smartphone addiction. Thus, further longitudinal studies are needed to explore the causal relation between these variables. Compared to cross-sectional designs, longitudinal designs can shed light on the long-term directionality of the link among smartphone addiction, stress, academic performance, and satisfaction with life.

In addition to potential effects on cognitive functioning and academic performance, an increasing number of researchers have found that smartphone use has a detrimental impact on mental health, including depression, anxiety, and stress, and on sleep quality (Bickham, Hswen, & Rich, 2015; Muusses, Finkenauer, Kerkhof, & Billedo, 2014; Samaha & Hawi, 2016; Thomée, Härenstam, & Hagberg, 2011). Bickham et al. (2015), for example, examined the longitudinal association between different media use and depression symptoms among adolescents. They recruited a sample of 126 young people and assessed different types of media use, such as smartphones, TV, computers, video games, and music. Participants were asked to estimate the total time spent on media per day and to complete time-use diaries (TUDs) over several randomly-assigned days. They were also asked to report their media use in real time using a technique called ecological momentary assessment (EMA). Participants were texted several times per day and were asked to respond with the amount of media use they had engaged in the hour prior to receiving the text. Depression was assessed using the Beck Depression Inventory for Primary Care. One year later, media use and depression were measured again. After controlling for baseline depression, participants who reported spending more time on their smartphone and watching TV at baseline had higher depression scores at the one-year follow-up There was no association between other media use such as computer use, music listening, and video game play and level of depression at follow-up. The authors concluded that excessive smartphone use and TV viewing were risk factors for depression in adolescents.

To explore the mechanisms behind problematic smartphone use, Elhai, Levine, Dvorak, and Hall (2016) conducted a retrospective study examining whether young adults' smartphone use was associated with symptoms of anxiety or depression, fear of missing out (FoMO), and the need for touch. To measure frequency of smartphone use, participants (n = 308) were asked to report how often they used 11 smartphone features, such as instant messaging, games, and social networking. To measure problematic smartphone use, participants were asked to complete the Smartphone Addiction Scale (Kwon et al., 2013). They also completed measures of depression and anxiety, fear of missing out, and the need for touch. Elhai et al. found that participants who had higher levels of problematic smartphone use were more likely to report higher levels of anxiety, while those who used their smartphones most frequently were more likely to report higher levels of depression. In addition, variables such as FoMO and need for touch were predictors of problematic smartphone use: individuals who had higher levels of FoMO or higher desires to touch their phones were more likely to be addicted to their smartphones.

In another study, Liu et al. (2018) investigated the mediating process and moderating process between stress and problematic smartphone use. They used self-control as the mediator and mindfulness as the moderator. Adolescents (n = 899) from a Chinese senior high school were asked to complete the survey together in classroom groups. Liu et al. measured perceived stress using the 7 items related to stress from the Chinese version of the Depression Anxiety Stress Scale (DASS), problematic smartphone use using the Mobile Phone Addiction Index (MPAI), self-control using the Self-control Scale (Dong & Lin, 2011), and mindfulness using the Child and Adolescent Mindfulness Measure (CAMM) developed by Greco, Baer, and Smith (2011). Perceived stress was positively correlated with problematic smartphone use. Individuals who had higher levels of perceived stress tended to be more addicted to their smartphone. Liu et al. also found that this effect was stronger for participants with lower levels of self-control and mindfulness. Liu et al. concluded that individuals with perceived stress were more likely to have difficulties in maintaining their self-control, which led to their smartphone addiction, while mindfulness worked as a buffer diminishing the relation between perceived stress and smartphone addiction.

Apart from the negative effects of smartphone use on mental health, excessive smartphone use has also been shown to be associated with sleep disturbance. For example, Thomée et al. (2011) conducted a prospective study examining young adults' smartphone use, mental health, and sleep quality. Young adults (n = 4156) aged between 20 and 24 years completed a baseline questionnaire in which they were asked about the frequency and consequences of their smartphone use including things like being woken up at night by their smartphone. Participants also completed measures of mental health including symptoms of stress, depression, and sleep disorders. One year later, participants completed the same measures of smartphone use and mental health. Based on their frequency of smartphone use, participants were assigned to one of three smartphone use categories: high, medium, or low. Compared with low-frequency smartphone users at baseline, high-frequency users reported higher levels of sleep disturbances and depression symptoms at the 1-year follow-up. In addition, participants who reported that it was stressful to be accessible via their smartphone were more likely to report mental health symptoms at follow-up. On the basis of their data, Thomée et al. concluded that high frequency smartphone use may be a risk factor for the development of sleep disturbances and symptoms of depression, particularly for those individuals who perceive accessibility via smartphones to be stressful.

In Thomée et al.'s (2011) study, participants merely estimated their smartphone use. Christensen et al. (2016), on the other hand, used an objective measure of smartphone use to explore the association between smartphone use and sleep. Christensen et al. asked participants (n = 56) to install an app on their smartphones to measure patterns of smartphone screen-time over a 30-day period. Sleep, including sleep duration, quality, wake-up time, and bedtime, was measured using the Pittsburgh Sleep Quality Index (PSQI). Participants whose total PSQI score > 5 were defined as having poor sleep quality. Christensen et al. found that poor sleep quality was associated with screen-time at and after bedtime. Specifically, individuals with poor sleep quality were more likely to spend time on their smartphone at or after bedtime. This finding suggests that smartphone screen time has a negative impact on sleep quality, however, given the correlational nature of Christensen et al.'s study, further research is needed to investigate whether there is a causal link between smartphone screen time and sleep quality.

Effect of interventions on smartphone use

Considering the increasing dependence on smartphones and the negative effects of excessive smartphone use, researchers have started investigating interventions to reduce individuals' smartphone use (e.g., Chun, 2018; Ko et al., 2015; Palokangas & Suomala, 2017). In one qualitative study, Chun (2018) examined how female adolescents with smartphone addiction conceptualized interventions for reducing smartphone use. Korean female adolescents (*n* = 36) who were receiving treatment at an Internet addiction centre were asked to take part in a brainstorming session to come up with strategies to help them reduce smartphone overuse. Two of the participants then reviewed all of the strategies and identified 29 that were unique. One month later, all of the participants were asked to sort the strategies in to categories and to then use a 5-point Likert scale to rate how important they thought each strategy would be in helping them decrease smartphone use. Based on the sorting and rating procedure, Chun reported five conceptual domain strategies identified by female adolescents as being important for reducing smartphone use. In order of importance, these were: self-awareness/self-control (e.g., "When I think that I have spent too much time using a smartphone"), involuntary restriction (e.g., "When there is no data remaining"), school restriction (e.g., "When my school bans smartphones on campus"), professional services (e.g., "Group counselling program provided by professional organizations") and peer support (e.g., "When friends take my smartphone away from me due to my overuse"). Chun concluded that any intervention designed to reduce smartphone addiction should include components that promote self-awareness and self-regulation.

To date, there are only a handful of studies where researchers have specifically tested the effectiveness of interventions to reduce smartphone overuse. In one study, Palokangas and Suomala (2017) investigated whether nudges would help smartphone users decrease their smartphone screen time. They recruited social media users who thought that they were addicted to their smartphone or spent too much time using it. The intervention consisted of five stages, each lasting one week. During the first week (Baseline stage), participants' screen time and screen unlocks were recorded using a smartphone app called Deglancer, which the researchers had developed to record smartphone use. Participants also completed a smartphone addiction scale. During the second week (Capability stage), every time participants unlocked their phones, they received a nudge that included the following information: 1) the amount of time that their phone had been locked before this unlock, 2) the number of unlocks so far that day, and 3) the total screen time so far that day. The purpose of the Capability stage was to determine whether the presentation of participants' usage information would influence their smartphone use. During the third week (Motivational stage), participants received similar nudges as during the Capability stage but this time, if participants had used their phones less than on the same day the previous week, they were presented with a positive thumbs up emoticon preceding the nudge. During the fourth week (Goal-attainment stage), participants were asked to set goals on the Deglancer app about how much they intended to decrease their smartphone usage for that week. Every time they achieved their goal, their achievement would be indicated via the same positive thumbs up emoticon used during the Motivational stage. During the fifth week (Observation stage), participants received no nudges. The purpose of the Observation stage was to determine whether participants' smartphone use would return to baseline levels once they stopped receiving nudges to reduce their use.

Regardless of whether participants received a high or a low score on the smartphone addiction scale completed during the baseline stage, all participants significantly reduced their smartphone screen time when they received nudges. This finding indicates that making smartphone users aware of their smartphone use was an effective trigger for them to change their excessive smartphone use. But researchers also found that when the nudges were removed, participants' smartphone use reverted back to baseline levels, indicating that the intervention was only effective when participants received nudges to reduce their smartphone use.

In another study, Ko et al. (2015) examined the effectiveness of a group-based intervention app called NUGU (No Use is Good Use) aimed at improving individuals' self-regulation of their smartphone use through social support. Ko et al. used online advertising to recruit 62 participants who were interested in reducing their smartphone use. Participants were assigned to either the NUGU-group condition or the NUGU-alone condition. Participants in the NUGU-group condition participated with close friends or family members; these participants were divided into 8 groups of 3-6 people. Participants in the NUGU-alone condition were not assigned to social support groups. The study was conducted over three weeks and included three stages: self-monitoring, self-setting, and social learning and competition. During the self-monitoring stage, the NUGU app presented users with details of their smartphone usage including their screen time during that day. During the self-setting stage, participants set goals on the app for reducing their smartphone use, for example, one goal might be around limiting use (e.g., 30 mins) during a particular activity (e.g., while at work). Once participants had set their goals, the app turned into goal mode and restricted access to other apps until participants had achieved their goals. If participants completed their goal, they earned points as well as congratulatory messages following goal completion. During the social learning and competition stage, participants in the NUGU-group condition were presented with their individual ranking within their group according to their weekly points and their ranking among the other groups. Each member also could check other users' completed goals or mission. Participants also completed measures of smartphone addiction during the first and last stages.

Although there were no significant differences between the two conditions in terms of the patterns of smartphone use before the intervention, after the intervention, Ko et al. (2015) found that participants in the NUGU-group condition significantly reduced their smartphone usage time and the number of app unlocks on their phones compared to participants in the

NUGU-alone condition. Regardless of condition, all participants' smartphone addiction scores reduced. Ko et al. concluded that NUGU provided an effective method of intervention, particularly when people were engaged in the intervention with groups rather than alone.

In both of the intervention studies described above, researchers demonstrated that interventions can be effective in reducing people's smartphone use, however, we could only find one study in which researchers have investigated whether an intervention to reduce smartphone use would also have a positive effect on people's mental health. In that study, Uhls et al. (2014) conducted a field study to explore whether reducing screen time improved preteens' understanding of nonverbal emotional cues. They recruited a group of 11- to 13-year-olds (n = 51) to spend 5 days at a nature camp with no access to television, computers, or smartphones. Another group of 11- to 13-year-olds (n = 54) served as a school-based control group; these participants had no restrictions placed on their media use. Children's daily media use was measured using the Media Use Questionnaire at the start of the study and children's interpretation of nonverbal emotion cues was measured using the Child and Adolescent Social Perception Measure (CASP) at the start of the study and at the end. At the start of the study, both groups reported that they spent almost 4.5 hours per day on media use, such as texting, watching TV, and playing videogames. Although the authors did not explicitly measure smartphone use during the intervention, it can be assumed that participants at camp did not use any technology while participants in the control group continued to use technology at the same rate as they did at the start of the study.

After five days at camp, participants in the experimental group showed significant improvements in their recognition of nonverbal emotion cues for both facial expressions and videotaped scenes, compared to participants in the control group. Uhls et al. (2014) concluded that even short-term reductions in screen time, allowing for increased opportunities for face-to-face social interactions, improved preteens' understanding of nonverbal emotional cues. Although the findings from this study are promising, the conclusions that we can draw from it are limited, however, because it is not clear whether it was the reduction in smartphone use per se or merely exposure to nature that led to the positive outcomes for children in the experimental group.

The current study

Given that there is a large body of literature showing that high frequency smartphone use is associated with a number of negative outcomes including poor academic performance, psychological well-being, and sleep quality, it is surprisingly that there has been no empirical research investigating whether decreasing screen time via an intervention reduces any of these negative outcomes. In the present study, we focused on examining whether introducing an intervention designed to reduce smartphone use would have a positive impact on people's psychological well-being. To do this, we recruited a sample of undergraduate students to take part in a study of smartphone use over three sessions. Participants completed measures of psychological wellbeing and their smartphone use was measured objectively using a smartphone app that recorded users' screen time and unlocks. After one week of baseline recording, we introduced a smartphone use reduction intervention before re-administering the measures of psychological wellbeing. Two weeks later, we measured participants' psychological wellbeing again.

In previous studies, researchers have shown that problematic smartphone use was negatively correlated with psychological well-being and individuals who were addicted to their smartphones were more likely to have lower levels of psychological well-being. Given this, we predicted that reductions in smartphone use would result in improvements in psychological well-being, particularly for those individuals whose psychological well-being was poor to start with. To test this prediction, we assigned participants to one of two symptomology groups according to their scores on clinical measures of depression and anxiety. We chose to focus on depression and anxiety because they are the most common mental disorders in New Zealand and around the world.

Method

Participants

We recruited 70 undergraduate students from the University of Otago to participate in this study. Participants were recruited via the Department of Psychology's Year 1 and Year 2 Experimental Participation Pool. They satisfied a small portion of course assessment by completing a worksheet based on the study. The only inclusion criteria for participation in this study was that participants were required to own and use a smartphone device. The final sample consisted of 60 participants, including 45 females (*M* age = 19.36, *SD* = 1.05), 15 males (*M* age = 19.53, *SD* = 0.99): 10 participants were excluded from the experiment because the phone app that we used to measure their phone usage failed to work. Participants identified as New Zealand European (55.6%), Māori (6.7%), Asian (15.5%), or "Other" (22.2%). All participants provided written, informed consent. The study was approved by the University of Otago Human Ethics Committee (approval number D18/067), which is accredited by the New Zealand Health Research Council and whose guidelines are consistent with those of the American Psychological Association.

Measures

Table 1 provides an overview of the battery of measures that we used in the present study.

Table 1

Measures used in the current study

Name	Authors	Items	Content description
Demographic questions*		3	Demographic information including sex, age, and ethnicity
Self-Reported Smartphone Use		2	Questions about amount of time using smartphone
Process and Social Usage of Smartphones*	Van Deursen et al. (2015)	12	Measures reasons for smartphone use
Smartphone Addiction Scale (SAS)*	Kwon et al. (2013)	33	Measures smartphone addiction
Habitual Smartphone behavior	Limayem et al. (2003)	6	Measures habitual smartphone behaviour
Fear of Missing Out Scale (FoMOs)*	Przybylski et al. (2013)	13	Measures the perception that others are engaged in more rewarding activities than the self
Brief Fear of Negative Evaluation Scale (BFNE)*	Leary (1983)	12	Measures social stress
Center for Epidemiological Studies Depression Scale (CES-D)	Radloff (1977)	20	Measures symptoms of depression
Hospital Anxiety and Depression Scale (HADS)	Zigmond & Snaith (1983)	7	Measures anxiety
Perceived Stress Scale (PSS)	Cohen & Williamson (1988)	10	Measures perceived stress
Flourishing Scale	Diener et al. (2010)	8	Measures perceived overall psychological well-being
Self-Regulation Scale	Diehl et al. (2006)	10	Measures self-regulation
Pittsburgh Sleep Quality Index (PSQI)	Buysse et al. (1989)	10	Measures sleep habits

* Measured only at Baseline.

Measures of smartphone behaviour

Smartphone usage. To measure participants' smartphone use, we asked participants to install one of two apps on their phone: *Moment* (www.inthemoment.io) for iPhone users or *QualityTime* (www.qualitytimeapp.com) for Android users. Both apps recorded similar daily phone usage data including the number of screen unlocks and the total amount of time that the phone was unlocked.

We also assessed smartphone use through two self-report questions. Participants were asked to use a 6-point scale (0 = Less than 1 hour per day to 5 = 5 or more hours per day) to estimate how many hours they used their smartphone on an average weekday or weekend (e.g., On an average weekday, how many hours do you spend on your smartphone?).

Process and social usage of smartphones. We assessed how participants used their smartphones using 12 questions from van Deursen, Bolle, Hegner, and Kommers (2015); seven items assessed the process use of smartphones (e.g., I use my smartphone because it's entertaining), and the remaining five items assessed the social use of smartphones (e.g., "I use my smartphone to interact with people"). Participants rated their agreement with each statement using a 5-point scale ranging from 1 (Strongly disagree) to 5 (Strongly agree). Participants' responses were then summed to create an overall process usage score ranging from 0-35 and an overall social usage score ranging from 0-25. Higher scores are indicative of greater smartphone usage for process- and socially-oriented purposes. Internal consistency[2] (Cronbach's α) was .68 and .67, pre- and post-intervention respectively.

Habitual use of smartphones. We assessed habitual smartphone behaviour using six questions from van Deursen et al. (2015). Participants were presented with statements (e.g. "I use my smartphone automatically") and rated their agreement with each statement using a 5-point scale ranging from 1 (Strongly disagree) to 5 (Strongly agree). Participants' responses

[2] The conventional benchmark for adequate internal consistency is .70.

were summed to create an overall score for each participant ranging from 6-30; higher scores indicated a higher level of habitual smartphone behaviour. Internal consistency (Cronbach's α) was .86 and .92, pre- and post-intervention respectively.

Smartphone addiction. We assessed addictive smartphone use using the 33-item Smartphone Addiction Scale (SAS; Min et al., 2013). The SAS is a measure of smartphone addiction, including daily-life disturbance, positive anticipation, withdrawal, cyberspace-oriented relationship, overuse, and tolerance. The scale consists of 33 statements (e.g., "I always think I should shorten my smartphone use") and participants rated how much they agreed with each statement using a 6-point scale (1= Strongly disagree and 6= Strongly agree). Participants' responses were summed over the 33 items to obtain an overall smartphone addiction score for each participant ranging from 33-198; higher scores indicate higher levels of smartphone addiction. Internal consistency (Cronbach's α) of the SAS was .89.

Measures of psychological well-being

Fear of missing out. We used the Fear of Missing Out Scale (FoMOs; Przybylski et al., 2013) measure to assess the extent to which participants perceive that other people around them are engaged in more rewarding social activities than they are. The FoMO consists of 10 statements (e.g., "I get worried when I find out my friends are having fun without me") and participants rated each statement on a 5-point scale ranging 1 (Not at all true of me) to 5 (Extremely true of me). Participants' responses were summed to create an overall score ranging from 13-65; higher scores indicate a greater fear of missing out. Internal consistency (Cronbach's α) of the FoMOs was .89.

Social stress. We assessed social stress using the Brief Fear of Negative Evaluation Scale (BFNE; Leary, 1983). The BFNE consists of 12 items (e.g., "When I am talking to someone, I worry about what they may be thinking about me") and participants rated how characteristic each statement was of them using a 5-point scale ranging from 1 (Not at all characteristic of me) to 5 (Extremely characteristic of me). Participants' responses were summed to create an overall score ranging from 12-60; higher scores indicate a higher level of social stress. Internal consistency (Cronbach's α) of the BFNE was .92.

Depressive symptoms. We assessed symptoms of depression using the Center for Epidemiological Studies Depression Scale (CES-D; Radloff, 1977). The CES-D consists of 20 statements (e.g., "I was bothered by things that don't usually bother me") and participants rated how frequently each item applied to them over the course of the past week using a 4-point scale ranging from 0 (Rarely or none of the time [< 1 day]) to 3 (Most or all of the time ([5-7 days]). Participants' responses were summed to obtain an overall score ranging from 0 – 60; higher scores indicate a greater experience of symptoms of depression. A cut-off score of 16 or greater is used to identify individuals at risk for clinical depression (Lewinsohn, Seeley, Roberts, & Allen, 1997). Internal consistency (Cronbach's α) was .89 and .90, pre- and post-intervention respectively.

Anxiety. We assessed anxiety using the Hospital Anxiety and Depression Scale (HADS; Zigmond & Snaith, 1983). The HADS consists of 14 statements, however, we only used the seven statements that relate to anxiety (e.g., 'I feel tense or 'wound up'"). Participants used a 4-point scale ranging from 0 (Not at all/only occasionally) to 3 (Most of the time/very often) to indicate the response that was closest to how they had been feeling over the last week. Participants' responses were summed to create an overall score ranging from 0 – 21; higher scores indicate higher levels of anxiety. A cut-off of 11 or greater can be used to identify individuals at risk for clinical anxiety (Zigmond & Snaith, 1983). Internal consistency (Cronbach's α) was .69 and .74, pre- and post-intervention respectively.

Perceived stress. We assessed perceived stress using the Perceived Stress Scale (PSS-10; Cohen & Williamson, 1988). The PSS-10 consists of 10 statements (e.g., "In the last month, how often have you felt confident about your ability to handle your personal problems?") and participants rated how often they experienced each statement using a 5-point scale ranging from 0 (Never) to 4 (Very often). Participants' responses were summed to create an overall perceived stress score ranging from 0 – 40; higher scores indicate higher overall levels of perceived stress. Internal consistency (Cronbach's α) was .83 and .87, pre- and post-intervention respectively.

Flourishing. We assessed flourishing using the Flourishing Scale (Diener et al., 2010). The Flourishing Scale is commonly used to assess overall psychological wellbeing including perceived sense of achievement in areas such as relationships, self-esteem, purpose, and optimism. The Flourishing Scale consists of eight statements (e.g., "I am a good person and live a good life") and participants rated how much they agreed with each statement using a 7-point scale ranging from 1 (Strongly disagree) to 7 (Strongly agree). Participants' scores were summed to create an overall flourishing score ranging from 8 - 56; higher scores indicate higher levels of available psychological resources and strength. Internal consistency (Cronbach's α) was .92 and .91, pre- and post-intervention respectively.

Self-regulation. We assessed self-regulation using the Self-Regulation Scale (Diehl, Semegon, & Schwarzer, 2004). This scale consists of ten statements (e.g., "I can concentrate on one activity for a long time, if necessary.") and participants rated each statement using a 4-point scale ranging from 1 (Not at all true of me) to 4 (Completely true of me). Participants' responses were summed to create an overall score ranging from 10 - 40; higher scores are indicative of better self-regulation. Internal consistency (Cronbach's α) was .82 and .85, pre- and post-intervention respectively.

Sleep quality. We assessed sleep quality using a modified version of the Pittsburgh Sleep Quality Index (PSQI; Buysse et al., 1989). The PSQI consists of 19 items; for five items, participants are asked to provide a written answer to questions such as, "During the last week[3], how many hours of actual sleep did you get at night?" and for the remaining 14 items (e.g., "During the past week, how much of a problem has it been for you to keep up enthusiasm to get things done?), participants rated how often they had experienced each item using a 4-point scale ranging from 0 (Not during the past week) to 3 (Three or more days in the past week). Participants' responses were summed to create a global sleep quality score ranging from 0 - 21; higher scores indicate poorer sleep quality and more sleep disturbance.

Procedure

Participants were tested individually over three sessions. The first two sessions lasted approximately 10 to 15 mins, while the final session lasted 15 to 20 mins.

Session 1 (Baseline). During the first baseline session, participants were told that the purpose of the study was to examine smartphone use in daily life. Following informed consent, participants completed a series of online questionnaires to collect demographic information (gender, ethnicity, and age) and to measure smartphone behaviour (self-reported smartphone use; habitual, process, and social smartphone use; smartphone addiction), and fear of missing out. Following completion of the questionnaires, participants were asked to install on their phone the app that we used to monitor their smartphone use: *Moment* (iOS) or *QualityTime* (Android). Participants were given instructions on how the app worked and were then asked to continue using their smartphones as they would normally for the next week.

Session 2 (Baseline). One week later, participants returned for the second baseline session. Participants answered another series of online questionnaires to measure social and perceived stress, symptoms of depression and anxiety, flourishing, self-regulation, sleep quality, and smartphone use. We also recorded their daily screen time and phone unlocks for each day since the first session of the study from the *Moment*/*QualityTime* app installed on

[3] In the original version of the PSQI, participants were asked about their sleep quality over the last month, however, to match the design of our study, we asked participants about their sleep quality over the last week. For this reason, we did not calculate internal consistency coefficients.

their smartphone. Participants were then told that the real purpose of the study was to examine whether they could reduce their smartphone use over the next two weeks. After describing why participants should reduce their smartphone use, the experimenter gave each participant a paper copy of a flyer describing some of the negative effects of high-frequency smartphone use (see Figure 1).

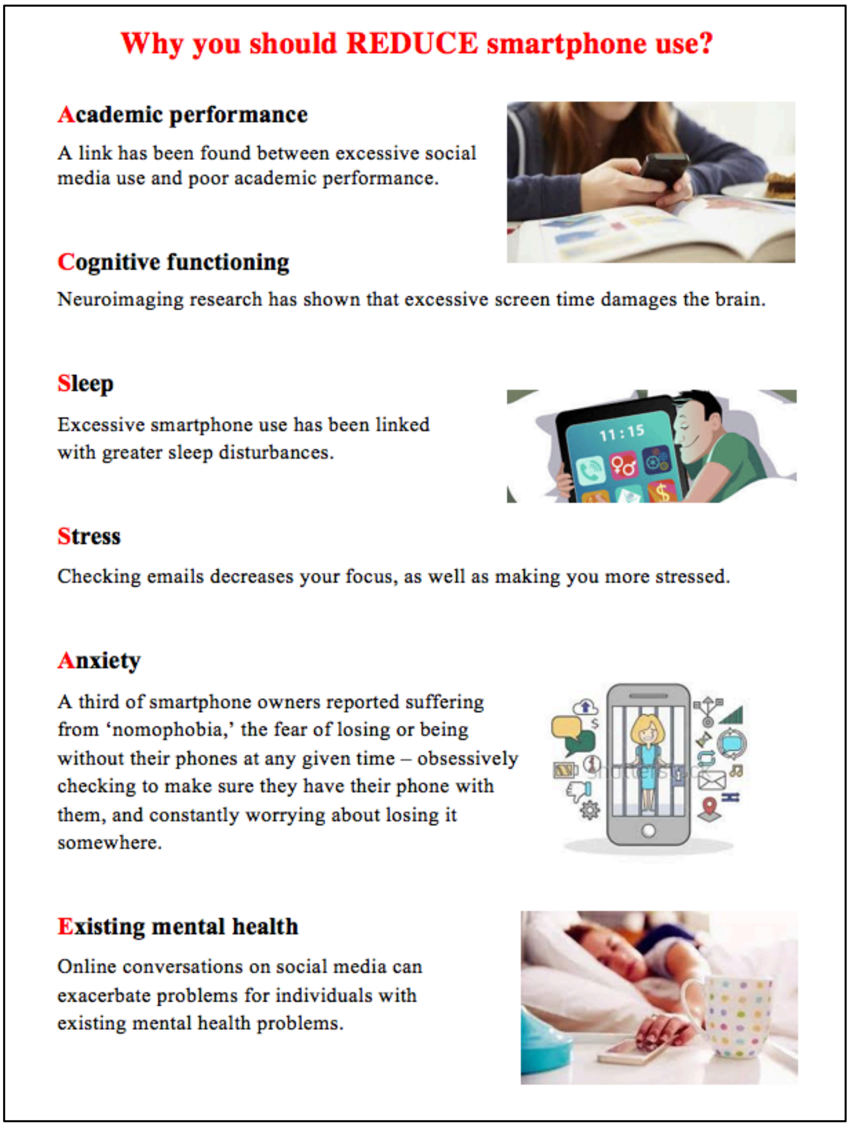

Figure 1. Flyer describing the negative effects of high-frequency smartphone use.

The experimenter then said, "What we want you to do over the next two weeks is to try to decrease your smartphone use. To help you do this, we have put together a list of tips that you can refer to." Participants then were given another paper copy of a flyer (and a wallet-sized reminder card) that contained a list of tips to help them decrease their smartphone use (see Figures 2 and 3). The experimenter went through the tips one by one with participants to ensure that they understood the information.

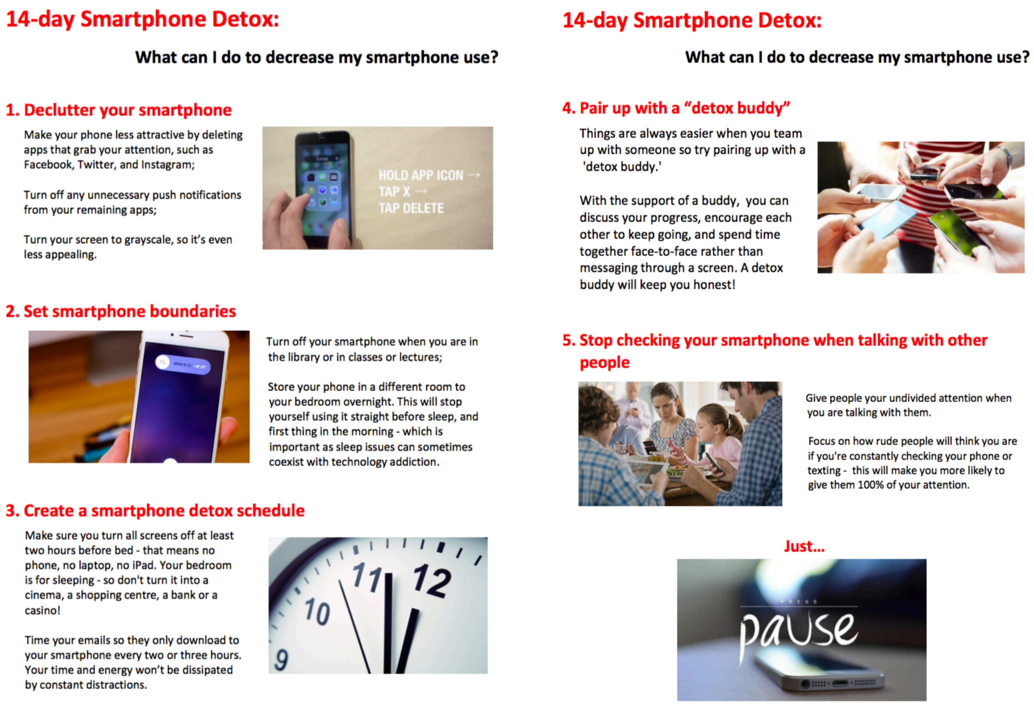

Figure 2. Flyer with tips to help participants decrease their smartphone use.

14-day Smartphone Detox:
What can I do to decrease my smartphone use?

1. **Declutter your smartphone**
2. **Set smartphone boundaries**
3. **Create a smartphone detox schedule**
4. **Pair up with a "detox buddy"**
5. **Stop checking your smartphone when talking with other people**

Figure 3. Reminder card with tips to help participants decrease their smartphone use.

Session 3 (Post-Intervention). Following the 2-week intervention period, participants returned to the laboratory to complete the post-intervention questionnaire. The questionnaire included the same measures that the participants had completed in Sessions 1 and 2 excluding the demographic questions and the questions about reasons for smartphone use, smartphone addiction, fear of missing out, and social stress. Again, we used data from the *Moment*/*QualityTime* app to record participants' daily screen time and phone unlocks for each day during the 2-week intervention period. Finally, as part of the debriefing, we asked participants a series of verbal questions to explore their experience in the study:

1. Did you try to reduce your smartphone use during the first week? If so, why?
2. We listed several reasons why you should reduce your smartphone use. Which ones motivated you the most?
3. Which of the 5 tips were the most effective in helping you reduce your smartphone use? Why?
4. List the three apps or functions that you use your smartphone for most?
5. Will you continue to do the Smartphone Detox?

The interview in Session 3 was audio-recorded. At the end of Session 3, participants were thanked for their participation and de-briefed.

Results

Descriptive Statistics

Based on the interview conducted at the end of the study, almost all participants (91%) reported that the most common use for their smartphones was social networking on apps such as Snapchat, Facebook, and Instagram. In terms of the smartphone intervention, the majority of participants (83%) reported that they had not tried to reduce their smartphone use during the first week of the study when their smartphone was being monitored to establish their baseline use. Although the remaining participants reported that they reduced their smartphone use during the first week of the study, they indicated that this was only on the first day when they were aware of the monitoring app, but after that, they forgot about the app and used their smartphones as they would normally for the rest of the week. The majority of participants (67%) said that academic performance was their primary motivation for reducing their smartphone use, followed by sleep quality (52%), and mental health problems (28%) such as depression, anxiety, or stress. Half of the participants (51%) reported that the tip that they found most useful in reducing their smartphone use was to stop checking their smartphones when talking with other people, followed by setting smartphone-use boundaries (40%), and decluttering their smartphone by deleting apps or stopping notifications (34%). When asked if they would continue with the smartphone detox after the end of the study, most participants (80%) indicated that they would continue reducing their smartphone use afterwards; the remaining participants indicated that they were not sure whether they would continue trying to reduce their smartphone use after the study, but that they would keep the app installed on their phone to see how much time they used their smartphone every day.

Figure 4 shows participants' self-reported smartphone use prior to and after the intervention. Recall that to assess self-reported use, we asked participants to use a 6-point scale (0 = Less than 1 hour per day to 5 = 5 or more hours per day) to rate how many hours they used their smartphone on an average weekday or weekend. As shown in Figure 4, prior to the introduction of the intervention (blue bars), the majority of participants indicated that they spent more than 3 hours per day on their smartphones on weekdays and more than 4 hours per day on weekends. These numbers reduced after the intervention (yellow bars). Overall, the average self-reported use rating on weekdays was 3.43 (SD = 1.18) and on weekends, 3.82 (SD = 1.08). After the intervention, participants' self-reported use decreased significantly to 2.67 (SD = 1.37, $t(59) = 3.77$, $p < .01$, $d = 0.49$, and 3.10 (SD = 1.41), $t(59) = 3.65$, $p < .01$, $d = 0.47$, on weekdays and weekends respectively. These decreases were confirmed by data obtained via the monitoring app installed on participants' smartphones (see below).

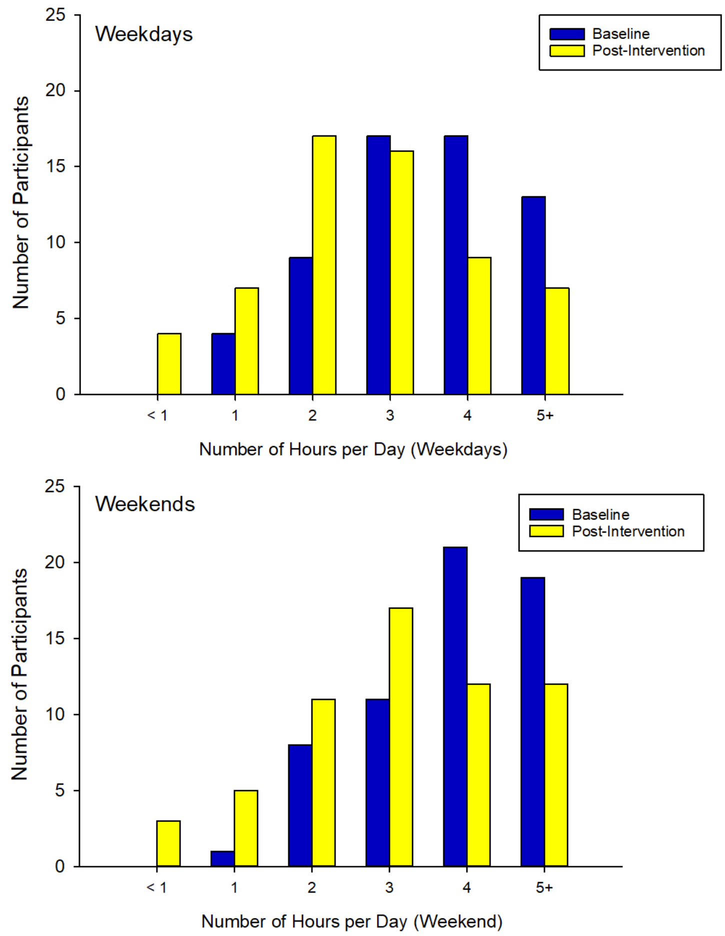

Figure 4. Top panel: Self-reported smartphone use on weekdays; Bottom panel: Self-reported smartphone use on weekends.

Effect of the Intervention

Recall that we hypothesised that reducing smartphone use might be particularly effective for participants who were already experiencing symptoms of depression and anxiety. To test this hypothesis, we assigned participants to groups based on their baseline depression and anxiety scores on the relevant measures.

Depression. Participants' scores on the CES-D ranged from 0 to 40 (maximum possible score = 60) with a mean score of 12.35 (SD = 8.35). So that we could compare the effectiveness of our smartphone intervention for participants who differed in how much they experienced symptoms of depression, we used the CES-D cut-off scores proposed by Lewinsohn et al. (1997) to assign participants to one of two depression symptomology groups. Participants who scored 15 or fewer on the CES-D were assigned to the Low Symptomology group (n = 42; M = 7.98, SD = 3.79) and participants who scored 16 or greater on the CES-D were assigned to the Mild-Moderate Symptomology group (n = 18; M = 22.56, SD = 7.05); participants in the Low group had significantly lower scores on the CES-D than did participants in the Mild-Moderate group, $t(21.34) = -8.28$, $p < .01$, $d = 3.58$.[4] Participants in the Low group also had significantly lower scores on the Fear of Missing Out Scale (FoMOs M = 58, SD = 6.99) and on the measure of social stress (BFNE M = 58, SD = 8.03) than did participants in the Mild-Moderate group (FoMOs M = 58, SD = 8.94; BFNE M = 42.67, SD = 9.49), smallest $t(58) = -2.90$, $p = .005$, $d = 0.76$. Participants in the Low group had significant higher scores (M = 5.29, SD = 2.75) on the Pittsburgh Sleep Quality Index (PSQI) than did participants in the Mild-Moderate group (M = 8.22, SD = 2.51), $t(58) = -3.88$, $p < .01$, $d = 1.11$. There were no differences between the two groups in terms of

[4] Because Levene's test for equality of variance indicated that the assumption of homogeneity of variance was violated for this analysis ($p < .002$), we conducted a Welch t-test instead. The degrees of freedom for the test are shown adjusted accordingly.

participants' age, $t(58) = 0.76$, $p = .45$, $d = 0.20$; or their gender, $\chi^2(1, n = 60) = 0.11$, $p = .75$, or ethnicity, $\chi^2(8, n = 60) = 4.57$, $p = .80$.

Table 2 shows descriptive statistics and between-subject *t*-tests for all baseline smartphone behaviour variables as a function of symptomology group. We used the data recorded by the smartphone monitoring apps, *Moment* (iOS) or *QualityTime* (Android), to calculate the amount of time that participants used their smartphones daily during the baseline and post-intervention time periods. Prior to the introduction of the intervention, participants had very similar patterns of smartphone use, regardless of whether they were in the Low or Mild-Moderate Symptomology groups. According to their score on the Smartphone Addiction Scale, they were not considered to be addicted to their smartphones, scoring, on average, at the mid-point of the scale.

Table 2

Descriptive statistics and independent t-tests for all smartphone behaviour variables measured at Baseline (pre-intervention) for participants in the Low and Mild-Moderate Depression Symptomology groups

		Low (n = 42)		Mild-Moderate (n = 18)			
Outcome	Max Score	*M*	*SD*	*M*	*SD*	Cohens *d*	*t*
Self-rated Smartphone Screen time†							
Weekday	5	3.52	1.11	3.22	1.35	0.24	.90
Weekend	5	3.83	.96	3.78	1.35	0.04	.16
Monitored Screen time hours per day		3.49	1.17	3.99	2.05	0.30	-1.20
Monitored Unlocks per day		91.66	45.30	88.56	51.28	0.06	.23
Smartphone Addiction	198	94.79	17.21	103.17	23.02	0.41	-1.56
Process Usage	35	26.93	3.13	27.78	3.39	0.26	-.94
Social Usage	25	22.02	2.50	22.67	2.30	0.27	-.93
Habitual behaviour	30	25.12	3.47	25.50	3.29	0.11	-.40

Note: M = Mean; *SD* = Standard Deviation; *CI* = Confidence Interval. †On a 6-point scale from 0-5 where 0 = less than one hour per day to 5 = 5 or more hours per day.

Next, we examined whether there were changes in participants' smartphone use after the introduction of the intervention. Tables 3 and 4 show descriptive statistics and within-subjects *t*-tests[5] for all baseline and post-intervention smartphone use variables for the Low and Mild-Moderate Symptomology groups, respectively (also see Figure 5). As shown in Table 3, participants in the Low group showed significant reductions in self-reported screen time on weekdays, $t(42) = 3.69$, $p = .001$, $d = 0.57$, and weekends, $t(42) = 3.70$, $p = .001$, $d = 0.57$, monitored screen time, $t(42) = 3.97$, $p < .001$, $d = 0.61$, and improvements in habitual behaviour, $t(42) = 3.54$, $p = .001$, $d = 0.55$, following the intervention, but they showed no significant improvements in monitored unlocks, $t(42) = 1.60$, $p = .12$, $d = 0.25$. When applying a more conservative Bonferroni correction of $p < .01$ (.05/5 tests), all of the differences remained statistically significant. In contrast, as shown in Table 4, participants in the Mild-Moderate group only showed a significant reduction in monitored screen time, $t(18) = 2.96$, $p = .009$, $d = 0.70$, and an improvement in habitual smartphone behaviour, $t(18) = 2.69$, $p = .016$, $d = 0.63$, but only the reduction in monitored screen time remained statistically significant after applying the Bonferroni correction of $p < .01$.

In summary, participants in both the Low and Mild-Moderate Depression Symptomology groups significantly reduced their smartphone use over the intervention and also reported that using their smartphone had become less of a habit.

[5] We also analysed participants' scores on all dependent measures using a series of mixed-factor 2 (Symptomology Group) X 2 (Session) analyses of variance (ANOVA); the outcomes of these analyses were virtually identical to when the data were analysed using t-tests.

Table 3

Descriptive statistics and paired t-test results comparing smartphone use variables across Baseline (pre-intervention) and Post-Intervention for participants in the Low Depression Symptomology group (n = 42)

	Baseline		Post-Intervention				95% *CI* for Mean Difference	
Outcome	*M*	*SD*	*M*	*SD*	% Change	Cohens *d*		*t*
Self-rated Smartphone Screen time								
Weekdays	3.52	1.11	2.64	1.27	-25.00	0.57	0.40, 1.36	3.69**
Weekend	3.83	.96	3.02	1.32	-14.20	0.57	0.37, 1.25	3.70**
Monitored Screen time hours per day	3.49	1.17	3.03	1.28	-13.18	0.61	0.23, 0.70	3.97**
Monitored Unlocks	91.66	45.30	85.76	52.87	-6.44	0.25	-1.55, 13.34	1.60
Habitual behaviour (D)	25.12	3.47	22.81	4.82	-9.20	0.55	0.99, 3.63	3.54**

Note: *$p < .05$, **$p < .01$. p values based on two-tailed t test. *M* = Mean; *SD* = Standard Deviation; *CI* = Confidence Interval; D = a decrease in score reflects improvement.

Table 4

Descriptive statistics and paired t-test results comparing smartphone use variables across Baseline (pre-intervention) and Post-Intervention for participants in the Mild-Moderate Depression Symptomology group (n = 18)

	Baseline		Post-Intervention				95% *CI* for Mean Difference	
Outcome	*M*	*SD*	*M*	*SD*	% Change	Cohens *d*		*t*
Self-rated Smartphone Screen time								
Weekdays	3.22	1.35	2.72	1.64	-15.53	0.30	-0.32, 1.32	1.28
Weekend	3.78	1.53	3.28	1.64	-13.23	0.28	-0.37, 1.37	1.21
Monitored Screen time hours per day	4.00	2.05	3.31	1.93	-17.16	0.70	0.20, 1.17	2.96**
Monitored Unlocks	88.56	51.28	79.25	48.84	-10.51	0.48	-0.43, 19.05	2.02
Habitual behaviour (D)	25.50	3.29	22.61	6.03	-11.33	0.63	0.62, 5.16	2.69*

Note: *$p < .05$, **$p < .01$. p values based on two-tailed t test. M = Mean; SD = Standard Deviation; CI = Confidence Interval; D = a decrease in score reflects improvement.

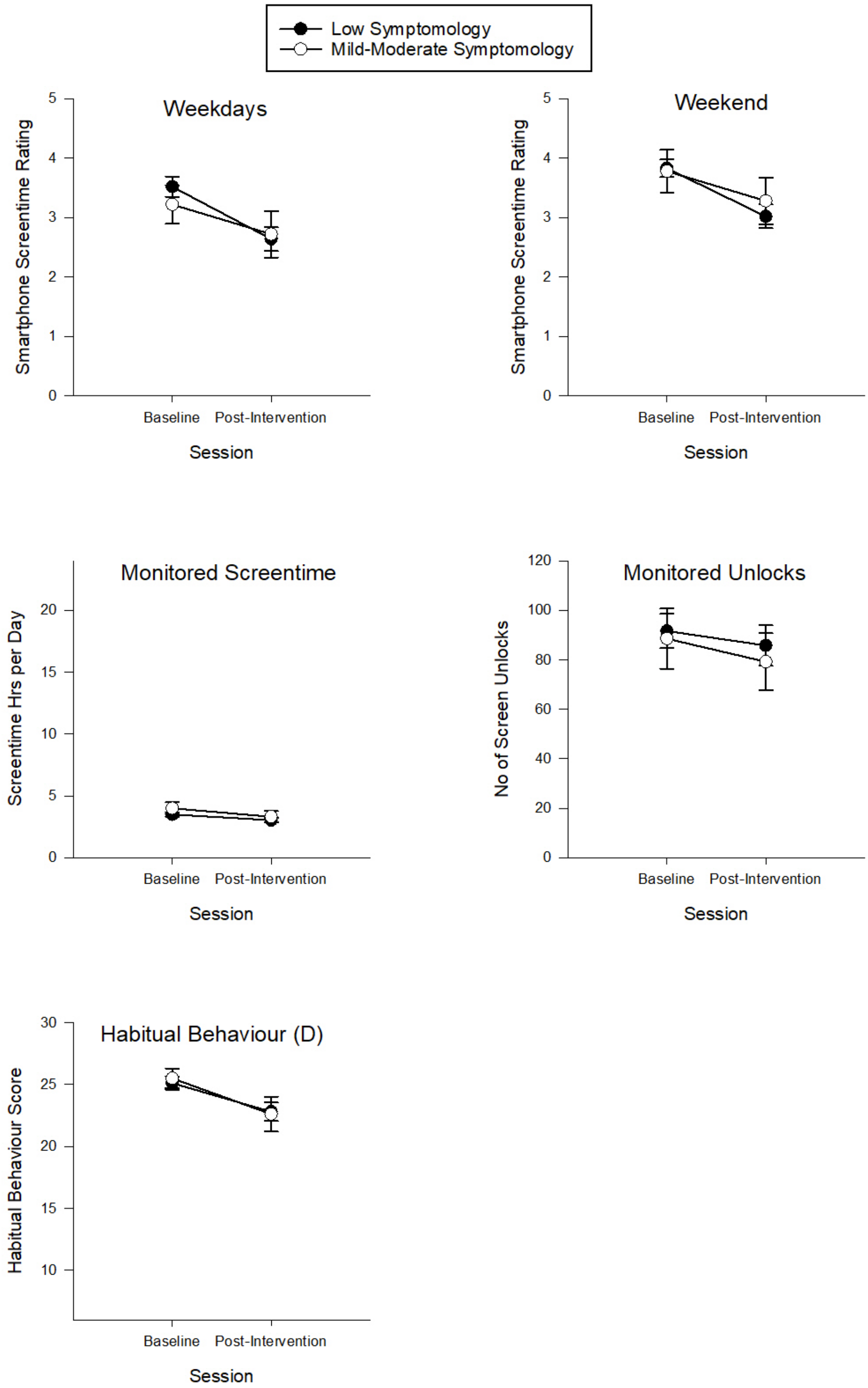

Figure 5. Participants' mean scores (+/-1SE) on the smartphone use variables as a function of Depression Symptomology group and Session. *Note*. D = a decrease in score reflects improvement.

Next, we examined whether there were changes in participants' psychological functioning after the introduction of the intervention. Tables 5 and 6 show descriptive statistics and within-subjects *t*-tests for all baseline and post-intervention psychological variables for the Low and Mild-Moderate Symptomology groups, respectively (see also Figure 6). As shown in Table 5, participants in the Low group showed significant improvements in self-regulation, $t(42) = -4.33$, $p < .01$, $d = 0.67$, which remained statistically significant after applying a Bonferroni correction of $p < .0083$ (.05/6 tests). There were no other significant changes in psychological outcomes for participants in the Low group.

In contrast, as shown in Table 6, participants in the Mild-Moderate group showed significant reductions in symptoms of depression, $t(18) = 2.30$, $p = .035$, $d = 0.54$, and perceived stress, $t(53) = 2.15$, $p = .046$, $d = 0.51$; and improvements in flourishing, $t(18) = -2.18$, $p = .043$, $d = 0.51$, and sleep quality, $t(18) = 3.31$, $p = .004$, $d = 0.78$, following the intervention, but they showed no reductions in anxiety, $t(18) = 1.58$, $p = .135$, $d = 0.37$, or improvements in self-regulation, $t(18) = -1.65$, $p = .12$, $d = 0.39$. When applying the more conservative Bonferroni correction of $p < .0083$, only the improvement in sleep quality remained significant.

Table 5

Descriptive statistics and paired t-test results comparing all psychological variables across Baseline (pre-intervention) and Post-Intervention for participants in the Low Depression Symptomology group (n = 42)

	Baseline		Post-Intervention				95% *CI* for Mean Difference	
Outcome	*M*	*SD*	*M*	*SD*	% Change	Cohens *d*		*t*
CES-Depression (D)	7.98	3.79	8.33	5.74	4.39	0.07	-1.87, 1.16	-.48
HADS-Anxiety (D)	5.93	2.31	5.76	3.00	-3.68	0.08	-0.49, 0.82	.51
Perceived stress (D)	13.45	5.15	13.57	5.66	0.89	0.03	-1.57, 1.33	-.17
Flourishing (I)	48.83	5.29	49.19	4.37	0.74	0.10	-1.45, 0.74	-.66
Self-regulation (I)	28.48	4.20	30.60	3.37	7.44	0.67	-3.11, -1.13	-4.33**
Sleep quality (D)	5.29	2.75	4.86	2.73	-8.13	0.19	-0.29, 1.14	1.21

Note: *$p < .05$, **$p < .01$. p values based on two-tailed t test. *M* = Mean; *SD* = Standard Deviation; *CI* = Confidence Interval; D = a decrease in score reflects improvement; I = an increase in score reflects improvement

Table 6

Descriptive statistics and paired t-test results comparing all psychological variables across Baseline (pre-intervention) and Post-Intervention for participants in the Mild-Moderate Depression Symptomology group (n = 18)

	Baseline		Post-Intervention				95% *CI* for Mean Difference	
Outcome	*M*	*SD*	*M*	*SD*	% Change	Cohens *d*		*t*
CES-Depression (D)	22.56	7.05	18.17	8.00	-19.46	0.54	0.36, 8.42	2.30*
HADS-Anxiety (D)	10.83	2.64	9.72	3.08	-10.25	0.37	-.385, 2.61	1.58
Perceived stress (D)	20.83	3.70	18.33	4.63	-11.08	0.51	0.04, 4.96	2.15*
Flourishing (I)	41.56	9.06	43.94	8.20	5.73	0.51	-4.70, -0.08	-2.18*
Self-regulation (I)	25.00	4.18	26.72	4.38	6.88	0.39	-3.93, 0.48	-1.65
Sleep quality (D)	8.22	2.51	6.94	2.21	-15.57	0.78	0.46, 2.09	3.31**

Note: $*p < .05$, $**p < .01$. p values based on two-tailed t test. M = Mean; SD = Standard Deviation; CI = Confidence Interval; D = a decrease in score reflects improvement; I = an increase in score reflects improvement

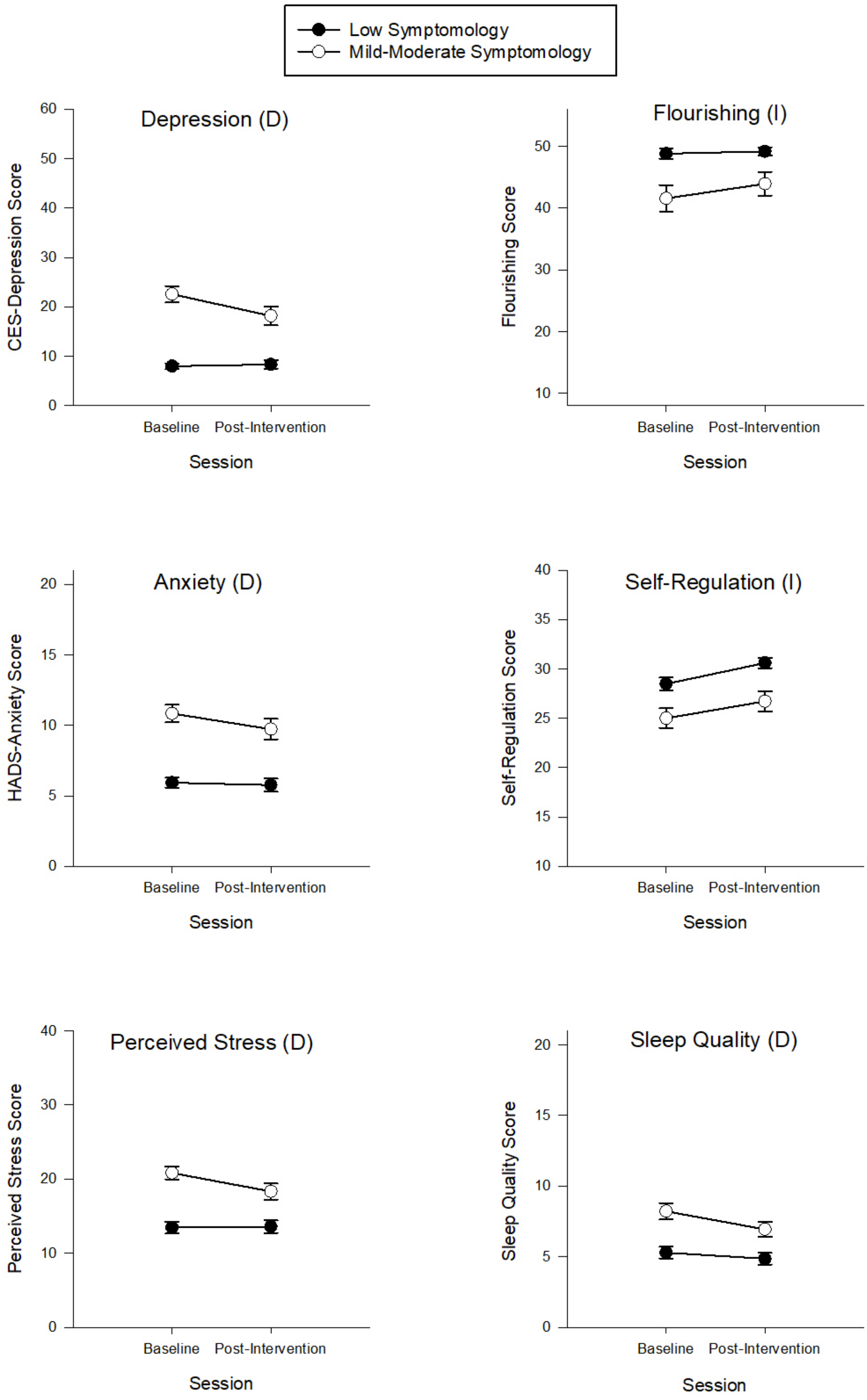

Figure 6. Participants' mean scores (+/-1SE) on the psychological variables as a function of Depression Symptomology group and Session. *Note*. D = a decrease in score reflects improvement; I = an increase in score reflects improvement.

Anxiety. In addition to depression, we also measured symptoms of anxiety using the HADS-A. Participants' scores on the HADS-A ranged from 1 to 14 (maximum possible score = 21) with a mean score of 7.40 (*SD* = 3.30). To compare the effectiveness of our smartphone intervention for participants who differed in how much they experienced symptoms of anxiety, we used the HADS-A cut-off scores proposed by Snaith and Zigmond (1994) to assign participants to one of two anxiety symptomology groups. Participants who scored 10 or fewer on the HADS-A were assigned to the Low Symptomology group ($n = 48$; $M = 6.15$, $SD = 2.29$) and participants who scored 11 or greater on the HADS-A were assigned to the Mild-Moderate Symptomology group ($n = 12$; $M = 12.42$, $SD = 1.24$); participants in the Low group had significantly lower scores on the HADS-A than did participants in the Mild-Moderate group, $t(58) = -12.88$, $p < .001$, $d = 3.40$. Participants in the Low group also had significant higher scores ($M = 5.50$, $SD = 2.74$) on the Pittsburgh Sleep Quality Index (PSQI) than did participants in the Mild-Moderate group ($M = 8.83$, $SD = 2.48$), $t(58) = -3.88$, $p < .01$, $d = 1.27$. There were no differences between the two groups on the Fear of Missing Out Scale (FoMOs), $t(58) = -0.76$, $p = .55$, $d = 0.24$, or on the measure of social stress (BFNE), $t(58) = -1.46$, $p = .23$, $d = 0.44$. There were also no differences in terms of participants' age, $t(58) = 0.88$, $p = .78$, $d = 0.26$; or their gender, $\chi^2(1, n = 60) = 0.56$, $p = .46$, or ethnicity, $\chi^2(6, n = 60) = 7.70$, $p = .26$.

Table 7 shows descriptive statistics and between-subject *t*-tests for all baseline smartphone behaviour variables as a function of symptomology group. Again, we used the data recorded by the smartphone monitoring apps to calculate the amount of time that participants used their smartphones daily during the baseline and post-intervention time periods. Prior to the introduction of the intervention, participants had very similar patterns of smartphone use, regardless of whether they were in the Low or Mild-Moderate Symptomology groups. According to their score on the Smartphone Addiction Scale, they were not considered to be addicted to their smartphones, scoring on average at the mid-point of the scale.

Table 7

Descriptive statistics and independent t-tests for all smartphone behaviour variables measured at Baseline (pre-intervention) for participants in the Low and Mild-Moderate Anxiety Symptomology groups

		Low (n = 48)		Mild-Moderate (n = 12)			
Outcome	Max Score	*M*	*SD*	*M*	*SD*	Cohens *d*	*t*
Self-rated Smartphone Screen time†							
Weekday	5	3.50	1.11	3.17	1.47	0.25	.87
Weekend	5	3.83	.98	3.75	1.49	0.06	.19
Monitored Screen time hours per day		3.50	1.31	4.22	2.12	0.43	-1.54
Monitored Unlocks per day		89.45	44.93	95.85	55.33	0.13	-.42
Smartphone Addiction	198	97.08	19.53	98.17	19.29	0.06	-.17
Process Usage	35	27.15	3.14	27.33	3.60	0.05	-.18
Social Usage	25	22.15	2.42	22.50	2.61	0.14	-.45
Habitual behaviour	30	25.23	3.50	25.25	3.05	0.01	-.02

Note: *$p < .05$, **$p < .01$. p values based on two-tailed t test. *M* = Mean; *SD* = Standard Deviation; *CI* = Confidence Interval. †On a 6-point scale from 0-5 where 0 = less than one hour per day to 5 = 5 or more hours per day.

Next, we examined whether there were changes in participants' smartphone use after the introduction of the intervention. Tables 8 and 9 show descriptive statistics and within-subjects *t*-tests for all baseline and post-intervention smartphone use variables for the Low and Mild-Moderate Symptomology groups, respectively (see also Figure 7). As shown in Table 8, participants in the Low group showed significant reductions in self-reported screen time on weekdays, $t(47) = 4.03$, $p < .001$, $d = 0.78$, and weekends, $t(47) = 4.16$, $p < .001$, $d = 0.77$, and in monitored screen time, $t(47) = 5.05$, $p < .001$, $d = 0.40$; and improvements in habitual behaviour, $t(47) = 4.29$, $p < .001$, $d = 0.59$, following the intervention, but they showed no significant improvements in monitored unlocks, $t(47) = 1.87$, $p = .068$, $d = 0.12$. When applying a more conservative Bonferroni correction of $p < .01$ (.05/5 tests), all of the differences remained statistically significant. In contrast, as shown in Table 9, participants in the Mild-Moderate group showed no significant reduction in self-reported screen time on weekdays nor weekends, $t(11) = -0.23$, $p = .82$, $d = 0.06$, monitored screen time, $t(11) = 1.35$, $p = .205$, $d = 0.24$, or monitored unlocks, $t(11) = 1.47$, $p = .171$, $d = 0.20$; nor did they show significant improvements in habitual smartphone use, $t(11) = 1.47$, $p = .171$, $d = 0.46$.

In summary, participants in the Low Anxiety Symptomology group significantly reduced their smartphone use over the intervention and also reported that using their smartphone had become less of a habit. Participants in the Mild-Moderate Anxiety Symptomology group, on the other hand, did not significantly reduce their smartphone use over the intervention, nor did they report that using their smartphone had become less of a habit.

Table 8

Descriptive statistics and paired t-test results comparing smartphone use variables across Baseline (pre-intervention) and Post-Intervention for participants in the Low Anxiety Symptomology group (n = 48)

	Baseline		Post-Intervention					
Outcome	*M*	*SD*	*M*	*SD*	% Change	Cohens *d*	95% *CI* for Mean Difference	*t*
Self-rated Smartphone Screen time								
Weekdays	3.50	1.11	2.54	1.35	-27.43	0.78	0.48, 1.44	4.03**
Weekend	3.83	0.98	2.92	1.41	-23.76	0.77	0.47, 1.36	4.16**
Monitored Screen time hours per day	3.50	1.31	2.94	1.45	-15.93	0.40	0.34, 0.78	5.05**
Monitored Unlocks	89.45	44.93	83.62	50.04	-6.52	0.12	-0.45, 12.11	1.87
Habitual behaviour (D)	25.23	3.50	22.67	5.03	-10.15	0.59	1.36, 3.76	4.29**

Note: *$p < .05$, **$p < .01$. *p* values based on two-tailed *t* test. *M* = Mean; *SD* = Standard Deviation; *CI* = Confidence Interval; D = a decrease in score reflects improvement.

Table 9

Descriptive statistics and paired t-test results comparing smartphone use variables across Baseline (pre-intervention) and Post-Intervention for participants in the Mild-Moderate Anxiety Symptomology group (n = 12)

	Baseline		Post-Intervention					
Outcome	*M*	*SD*	*M*	*SD*	% Change	Cohens *d*	95% *CI* for Mean Difference	*t*
Self-rated Smartphone Screen time								
Weekdays	3.17	1.47	3.17	1.40	0	0	-0.61, 0.61	.00
Weekend	3.75	1.49	3.83	1.19	2.13	0.06	-0.87, 0.71	-.23
Monitored Screen time hours per day	4.22	2.02	3.81	1.54	-9.72	0.24	-0.27, 1.11	1.35
Monitored Unlocks	95.85	55.33	84.57	58.77	-11.77	0.20	-5.65, 28.21	1.47
Habitual behaviour (D)	25.25	3.05	23.08	5.90	-8.59	0.46	-1.08, 5.42	1.47

Note: M = Mean; *SD* = Standard Deviation; *CI* = Confidence Interval; D = a decrease in score reflects improvement.

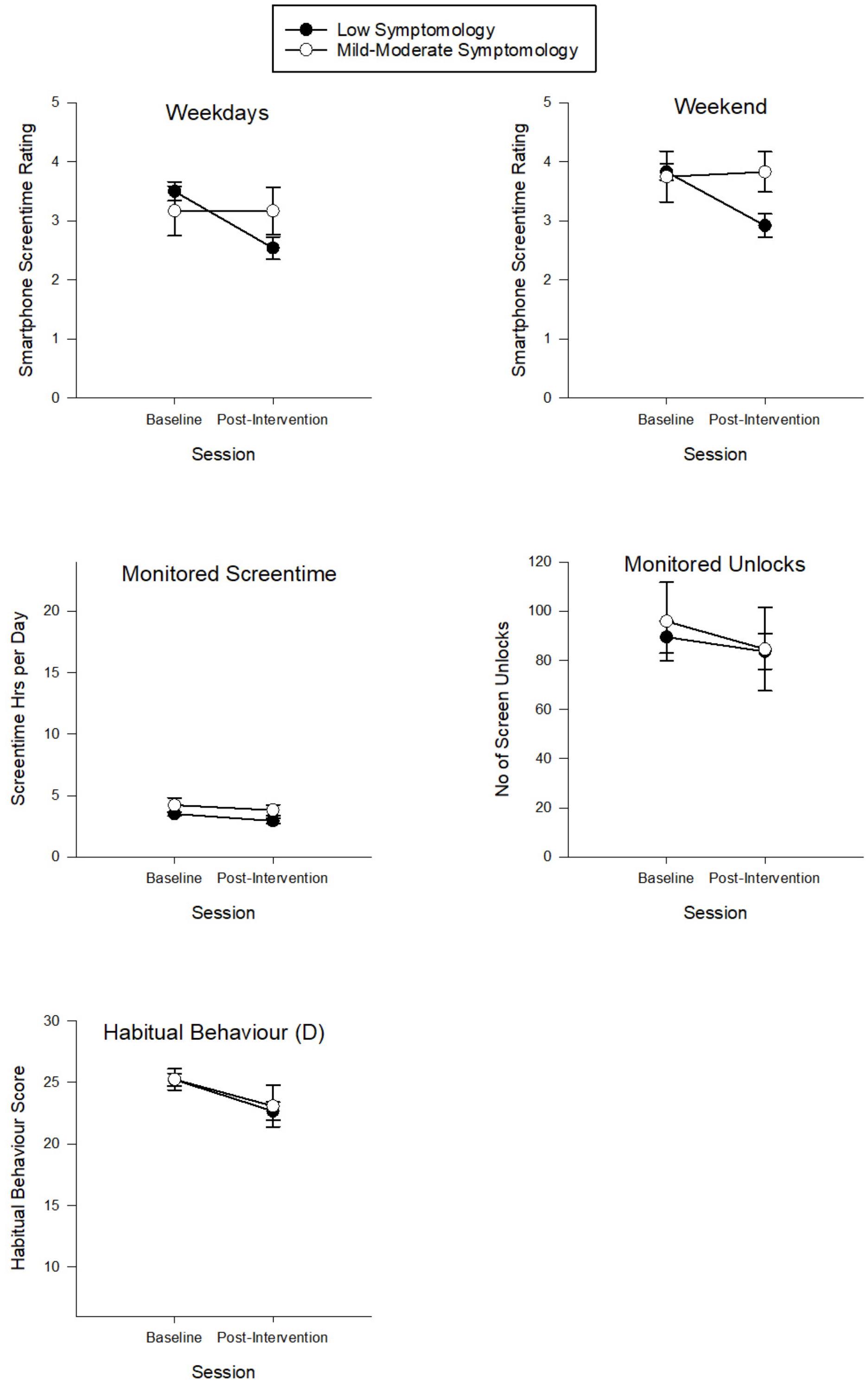

Figure 7. Participants' mean scores (+/-1SE) on the smartphone use variables as a function of Anxiety Symptomology group and Session. *Note*. D = a decrease in score reflects improvement.

Next, we examined whether there were changes in participants' psychological functioning after the introduction of the intervention. Tables 10 and 11 show descriptive statistics and within-subjects *t*-tests for all baseline and post-intervention psychological variables for the Low and Mild-Moderate Anxiety Symptomology groups, respectively (see also Figure 8). As shown in Table 10, participants in the Low group showed significant improvements in self-regulation, $t(47) = -4.19$, $p < .001$, $d = 0.49$, which remained statistically significant after applying a Bonferroni correction of $p < .0083$ (.05/6 tests). There were no other significant changes in psychological outcomes for participants in the Low group.

In contrast, as shown in Table 11, participants in the Mild-Moderate group showed significant reductions in symptoms of anxiety, $t(11) = 2.75$, $p = .019$, $d = 1.03$, as well as improvements in sleep quality, $t(11) = 2.31$, $p = .04$, $d = 0.48$, following the intervention, but they showed no reductions in depression, $t(18) = 1.81$, $p = .098$, $d = 0.57$, or perceived stress, $t(11) = 1.97$, $p = .074$, $d = 0.83$; and no improvement in flourishing, $t(11) = -1.55$, $p = .149$, $d = 0.35$, or self-regulation, $t(11) = -1.56$, $p = .146$, $d = 0.45$. When applying the more conservative Bonferroni correction of $p < .0083$, the improvements in symptoms of anxiety and sleep quality did not remain significant.

Table 10

Descriptive statistics and paired t-test results comparing all psychological variables across Baseline (pre-intervention) and Post-Intervention for participants in the Low Anxiety Symptomology group (n = 48)

	Baseline		Post-Intervention					
Outcome	*M*	*SD*	*M*	*SD*	% Change	Cohens *d*	95% *CI* for Mean Difference	*t*
CES-Depression (D)	10.19	6.78	10.00	7.56	-1.86	0.03	-1.36, 1.73	.24
HADS-Anxiety (D)	6.15	2.29	6.15	3.22	0	0	-.614, .614	.00
Perceived stress (D)	14.40	5.67	14.31	5.97	-0.63	0.02	-1.26, 1.42	.13
Flourishing (I)	47.38	7.53	48.02	6.05	1.35	0.09	-1.70, 0.41	-1.23
Self-regulation (I)	27.96	4.32	29.92	3.71	7.01	0.49	-2.90, -1.02	-4.19**
Sleep quality (D)	5.50	2.74	4.94	2.66	-10.18	0.21	-0.09, 1.21	1.75

Note: *p < .05, **p < .01. p values based on two-tailed t test. *M* = Mean; *SD* = Standard Deviation; *CI* = Confidence Interval; D = a decrease in score reflects improvement; I = an increase in score reflects improvement

Table 11

Descriptive statistics and paired t-test results comparing all psychological variables across Baseline (pre-intervention) and Post-Intervention for participants in the Mild-Moderate Anxiety Symptomology group (n = 12)

	Baseline		Post-Intervention				95% *CI* for Mean Difference	
Outcome	*M*	*SD*	*M*	*SD*	% Change	Cohens *d*		*t*
CES-Depression (D)	21.00	8.70	16.42	7.22	-21.81	0.57	-1.01, 10.17	1.81
HADS-Anxiety (D)	12.42	1.24	10.17	2.82	-18.12	1.03	0.45, 4.05	2.75*
Perceived stress (D)	20.75	3.14	17.75	4.03	-14.46	0.83	-.35, 6.35	1.97
Flourishing (I)	43.75	6.15	46.00	6.85	5.14	0.35	-5.45, .95	-1.55
Self-regulation (I)	25.33	4.58	27.50	5.04	8.57	0.45	-5.22, .88	-1.56
Sleep quality (D)	8.83	2.48	7.67	1.88	-13.14	0.48	0.06, 2.28	2.31*

Note: *$p < .05$, **$p < .01$. p values based on two-tailed t test. *M* = Mean; *SD* = Standard Deviation; *CI* = Confidence Interval; D = a decrease in score reflects improvement; I = an increase in score reflects improvement

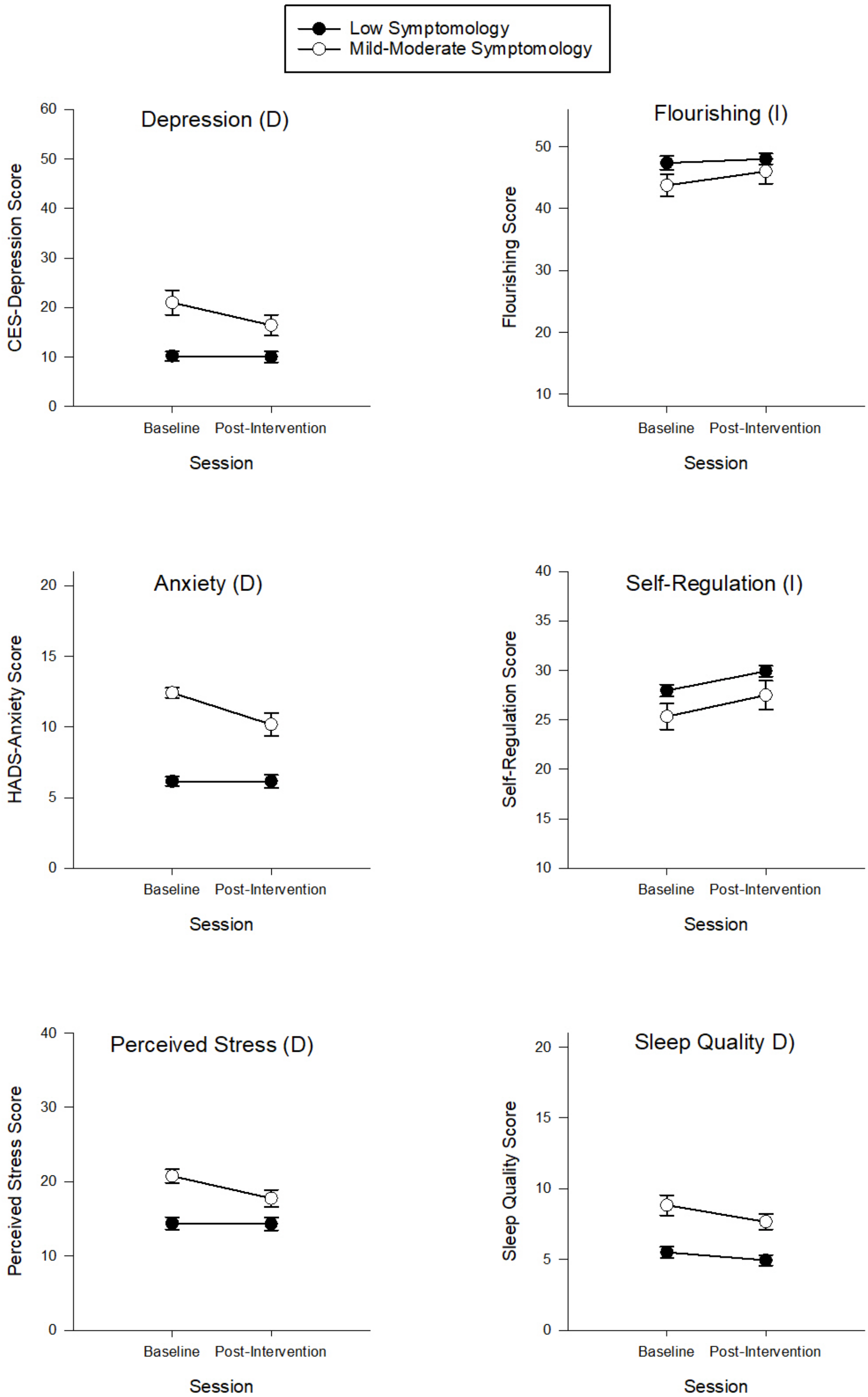

Figure 8. Participants' mean scores (+/-1SE) on the psychological variables as a function of Anxiety Symptomology group and Session. *Note*. D = a decrease in score reflects improvement; I = an increase in score reflects improvement.

Discussion

The aim of the current study was to investigate the impact of a 2-week intervention to reduce young adults' smartphone use on their psychological wellbeing. We used the cut-off scores on the Depression and Anxiety scales at baseline to assign people into Low and Mild-Moderate Symptomology groups. We hypothesised that, compared to individuals with fewer symptoms of depression and anxiety at baseline, individuals with greater symptoms of depression or anxiety would show greater improvements in their psychological well-being after the intervention. We found that with the exception of the group of participants who showed mild-moderate anxious symptoms at baseline, the majority of participants showed a reduction in their monitored smartphone screen time over the intervention. In terms of mental health, only participants whose levels of depression or anxiety were high to start with showed any improvements in their mental health following the intervention. In addition, participants with mild-moderate depressive symptoms not only showed improvements in their symptoms of depression but also showed improvements in their perceived stress, flourishing, and sleep quality. Participants with mild-moderate anxious symptoms not only showed improvements in their symptoms of anxiety but also showed improvements in their sleep quality, despite the fact that they did not significantly reduce their smartphone use during the intervention period. Overall, our findings provide some tentative support for the hypothesis that, compared to smartphone users with low depression or anxiety symptomology, reduction in smartphone use results in greater improvements in psychological well-being for people with high depression or anxiety symptomology.

Effectiveness of the intervention on reducing smartphone use

In the current study, we objectively measured participants' smartphone screen time using an app installed on their smartphone. At baseline, we found that participants were spending between 3 to 4 hours per day on their phones, a use time that is consistent with that reported in other studies that measured smartphone use in North American countries (Elhai et al., 2018; Rozgonjuk, Levine, Hall, & Elhai, 2018), while a bit lower than that in European countries (Andrews et al., 2015). After the intervention, even though on average, participants decreased their screen time to less than 3 hours per day, they were still using their smartphones for a relatively high proportion of their awake time. It is important to note that we probably underestimated people's screen time because we did not ask participants to report their time spent using other devices, such as laptops, tablets, etc.

As well as monitoring participants' screen time using an app on their phone, we also asked participants to estimate how much time they spent on their smartphones before and after the intervention. Self-report measures have been used widely in psychological research due to their ease of use. However, under some circumstances, self-report measures have been shown to yield inaccurate data (Boase & Ling, 2015). At baseline, we found that most participants estimated that they used their smartphone for more than 3 hours per day on weekdays, and more than 4 hours per day at weekend. After the intervention, most participants reported that they used their smartphone for less than 3 hours per day on weekdays, and less than 4 hours per day at weekends. Several participants even reported that they spent less than 1 hour per day on their phones after the intervention. Compared to monitored screen time, our results indicated that participants' self-reported estimation matched their actual smartphone use, and they were also aware of their reductions in smartphone use after the intervention. In a previous study, Andrews et al. (2015) explored the accuracy of participants' subjective smartphone use comparing with objective smartphone use. They found that estimated smartphone use was moderately correlated with real-world smartphone use. Although self-reported smartphone use may work as an adequate measure of use, smartphone monitoring apps might be more accurate tools to use to measure individuals' smartphone use.

In terms of smartphone addiction, although in their original study, Kwon et al. (2013) did not report a cut-off point for smartphone addiction, participants' mean Smartphone Addiction Scale (SAS) score was 110.02. In our study, we found that participants' mean scores on the SAS were below the midpoint of the total possible score, which was consistent with another recent study (Rozgonjuk et al., 2018). When considered together, our data suggest that although our participants spent considerable time on their smartphones, they were not particularly addicted to them. In future research, it will be important to continue to measure both time spent using devices as well as addiction. Clearly, the former measure is not necessarily a proxy for the latter.

Our findings suggested that the smartphone intervention was effective for the majority of young adults, helping them to decrease their smartphone screen time over the 2-week intervention. One possible reason for why our intervention might have been effective is that by providing participants with information about the negative effects of excessive smartphone use on academic performance, cognition, sleep, and mental health problems, we may have improved participants' knowledge regarding the negative consequences of smartphone overuse. This in turn may have increased participants' self-awareness of their smartphone use. Recall that in the study by Chun (2018), participants reported that they thought that self-awareness was the most useful strategy to reduce their smartphone overuse. In the present study, we increased participants' self-awareness through installing an app on their phones to measure smartphone use. Being aware of their smartphone use via the app may have led participants to decrease their use. Prior research has shown that participants tend to reduce their smartphone use when they receive feedback about how much time they have already spent on their phones. Palokangas and Suomala (2017), for example, found that after they provided participants with nudges (i.e., feedback) concerning their real-time smartphone use, participants significantly decreased their smartphone use compared to at baseline. Moreover, we also provided participants with 5 tips on how to decrease their smartphone use. For example, we encouraged participants to "Stop checking your phone when talking with other people." Given that we did not evaluate the effectiveness of each strategy separately, future research is needed to explore which, and how many, of the tips are required to reduce smartphone use.

Although participants with mild-moderate symptoms of anxiety decreased their smartphone use by up to 10% on average after the intervention, the decrease in smartphone use was not significant. We suspect that this finding might be due to the small sample size in that group (n = 12). In future, researchers should recruit more participants with symptoms of anxiety to examine the effectiveness of smartphone intervention in reducing screen time. Alternatively, however, we found that participants in the mild-moderate anxiety symptomology group spent more than 4 hours per day on their smartphones at baseline. Compared to other participants, participants with anxiety might rely more on their phones and be more reluctant to reduce their smartphone use, especially through a very brief and simple intervention. In other words, although we provided participants with several tips to help them decrease their phone use, these tips may not be effective for those who are anxious and who already spend considerable time on their smartphones. For example, during our intervention, we encouraged participants to turn off their smartphones when they were in the library or in lectures, but previous studies have shown that some individuals experienced increased levels of anxiety even after a short period of separation from their devices (Cheever et al., 2014; Clayton et al., 2015). Obviously, for participants who are already experiencing symptoms of anxiety, setting smartphone boundaries might not be an effective strategy for decreasing smartphone use.

Regardless of baseline symptoms of depression or anxiety, we did not find that participants decreased their screen unlocks after the intervention. This finding is consistent with that of Palokangas and Suomala (2017) who examined the effectiveness of different types of nudges to lower smartphone overuse. Participants in that study showed significant reductions in their total screen time but no reduction in the number of unlocks. Compared to monitored screen time, number of unlocks is perhaps not an appropriate indicator of reductions in smartphone use. Unlike screen time, number of unlocks might reflect individuals' automatic and habitual behaviour (Van Deursen et al., 2015), which is difficult to change during a short intervention period.

Effect of smartphone intervention on psychological well-being

After the 2-week smartphone intervention, we found that participants with mild-moderate symptoms of depression not only showed significant improvements in their depressive symptoms, but also showed improvements in other measures of psychological well-being such as perceived stress, flourishing, and sleep quality. These findings suggest that reducing smartphone use might result in improvements in psychological well-being, at least for people who already exhibit higher levels of depression. For participants with mild-moderate symptoms of anxiety, although they reduced their smartphone use after the intervention, this decrease was not statistically significant. Despite this, they still showed significant improvements in their symptoms of anxiety, as well as in sleep quality. It is possible that for those participants with mild-moderate symptoms of anxiety, even a small (nonsignificant) reduction in smartphone use was sufficient to lead to improvements in their psychological well-being. More studies are needed to examine this finding in the future. It is also possible that improvements in psychological well-being for participants with mild-moderate symptoms of anxiety were not due to the reduction in screen time, per se. In other words, reduction in smartphone use might have an indirect effect on mental health.

Before the intervention, we found that participants with greater symptoms of depression or anxiety also reported poorer sleep quality than those who had fewer symptoms. After the intervention, those people showed significant improvements in their sleep quality, irrespective of whether they significantly decreased their smartphone time during the intervention. This finding is consistent with the findings of a study by Adams and Kisler (2013) who found that sleep quality mediated the correlation between technology use before bedtime and psychological well-being--depression and anxiety. Our findings could help explain how smartphone use indirectly affected individuals' mental health. People who overuse their smartphones are also more likely to use their phones before bedtime, which has been shown to have a negative impact on sleep quality and consequently, mental health (e.g., Demirci et al., 2015). Poor sleep might then lead to mental health problems, such as depression and anxiety. Actually, the majority of participants in the current study knew about the negative impact of problematic smartphone use on their sleep quality. During our smartphone intervention, we provided each participant with a flyer showing several negative effects of excessive smartphone use including poor sleep quality. Participants reported that sleep quality was the second most common motivating factor for them to decrease their smartphone use. We also provided participants several tips to reduce their smartphone use, for example, storing smartphones in a different room to their bedroom overnight, to stop them using their phones before sleep. Nevertheless, further research is necessary to understand the mechanism behind the relations between smartphone use, sleep quality, and mental health.

Our findings also indicated that reducing smartphone use for participants who showed fewer symptoms of depression or anxiety at baseline did not result in any improvements in their psychological well-being. This finding is probably due to a floor effect – if participants already experienced good mental health at baseline, even though their smartphone use decreased as a result of the intervention, there might not be as much room for them to improve their mental health. This finding in turn indicates that although technology use, such as smartphone use may cause impairments for certain people, smartphone use per se may not be as detrimental as we think, especially for mentally-well people.

According to Compensatory Internet Use theory (Kardefelt-Winther, 2014), motivation for smartphone use may provide a perspective to explain why smartphone use only results in impariment for individuals with symptoms of depression or anxiety. Compared to people with fewer symptoms, people with greater symptoms of depression or anxiety have been shown to have difficulty regulating their emotions (Elhai et al., 2016). It is possible, therefore, that they use smartphones as a coping mechanism to relieve their negative moods (Kardefelt-Winther, 2014). For example, depressed people are more likely to overuse smartphones to alleviate their depressive emotions (Kim, Seo, & David, 2015), despite the fact that this ineffective coping strategy might lead to negative outcomes. Chen et al. (2017) conducted a study to explore the role that different motivations play in the development of smartphone addiction. They found that participants who used their smartphones to reduce negative feelings were more likely to develop smartphone addiction than were other people. It is entirely possible that alleviating psychological problems might not be the main motivation for individuals with fewer symptoms of depression and anxiety to use their smartphones. Thus, although they significantly decreased their smartphone use, their psychological well-being remained the same.

Similarly, boredom inclination, also called boredom proneness, is another type of motivation that is positively associated with smartphone addiction (Chen et al., 2017). Chen et al. found that smartphone users who were engaged in using their devices as a pastime were more likely to be addicted to their devices. Like mood regulation mentioned earlier, boredom proneness has been found to be related to both depression and anxiety (Elhai et al., 2017; Struk et al., 2017). People with higher levels of depression and anxiety tended to overuse smartphones as a way to avoid their boredom. Individuals with fewer symptoms of depression and anxiety were less likely to use their devices as a pastime. Thus, although they reduced their smartphone use, their psychological mental health did not improve significantly.

There is some evidence to suggest that there is a bidirectional relation between problematic smartphone use and mental health problems, such as depression and anxiety (Yen et al., 2012). On the one hand, problematic smartphone use could be driven by individuals' mental health problems, and on the other hand, mental health problems could be further driven by individuals' problematic smartphone use. As a result, compared to mentally-well people, people who already have mental health problems are more likely to suffer from the negative consequences of smartphone overuse. Overall, our study showed that compared to people with lower levels of mental-health difficulty, participants who had higher levels of mental health at baseline showed greater improvements in psychological well-being after they reduced their smartphone use.

Strengths, limitations, and future directions

Although several studies have examined either the correlation between smartphone use and mental health, or the effectiveness of smartphone interventions designed to decrease smartphone use, our study is the first to investigate whether reducing smartphone use leads to improvements in psychological well-being. Our findings indicated that most participants significantly decreased their screen time after the introduction of a simple intervention, but only participants with more symptoms of depression or anxiety at baseline showed significant improvements in their psychological well-being following the intervention. Thus, whether reduction in smartphone use contributes to psychological well-being might depend on individuals' current mental-health status. Furthermore, our results suggested that sleep quality is a significant variable to consider if we want to have a deeper understanding of the association between smartphone use and psychological well-being.

We acknowledge that our study had several limitations. First, our sample was restricted to a small nonclinical population, limiting our ability to generalise our findings beyond this particular population. In the future, researchers should include larger, nonstudent populations to examine the effectiveness of this smartphone intervention, including with groups of clinically-depressed and clinically-anxious individuals. We predict that our effects would be the same or larger in these clinical samples, but this prediction remains to be tested. Second, although we found that participants reduced their smartphone use after the intervention, we did not measure their time spent using other devices (e.g., laptops, tablets, etc.) during the intervention period. We assumed that participants would not compensate for decreasing their smartphone use by increasing their time on other devices since they were told the negative effects of excessive smartphone (technology) use. In future research, researchers could first examine whether people are actually substituting their smartphone use with other devices, and then design new interventions to decrease individuals' screen time on different devices. Finally, whether our intervention would continue to have the same effect over the long term remains to be determined. In Palokangas and Suomala's (2017) smartphone intervention study, for example, as soon as participants stopped receiving nudges to reduce their smartphone use, participants' smartphone use increased back up to baseline levels. In future research, researchers should examine the effectiveness of interventions over much longer time periods.

Conclusion

In conclusion, the research described in the current thesis represents the first empirical examination of the impact of a smartphone intervention on mental health in daily life. This preliminary investigation suggests that reductions in smartphone use are associated with improvements in symptoms of depression and anxiety for people who already showed these symptoms. Although people with better levels of mental health decreased their smartphone use, their psychological well-being remained the same. Our findings suggest that smartphone use per se might not be as detrimental as we think especially for people who are already mentally well. Although additional research is warranted, we conclude that there is validity to the notion that reductions in smartphone use has therapeutic value for those who are already exhibited some mental health symptoms.

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